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Observations on the Stone Crab

Menippe mercenaria Say,

In the Vicinity of Port Aransas, Texas

by

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INTRODUCTION

Observations on the stone crab, *Menippe mercenaria* Say, were started on December 16, 1947. The purpose of these observations was to study the natural history and behavior of this crab, with special reference to its importance as an oyster predator. Plans called for some simple laboratory experimentation and monthly field observations. Although the regularity of the observations was interrupted for various reasons, some information gained which may interest workers is herewith presented.

GENERAL INFORMATION

Distribution

Although the Cuban stone crab, *M. nodifrons* Stimpson, has been reported from Indian River, Florida, and from Cameron, Louisiana (Rathbun 1930), *M. mercenaria* is the only one common on the South Atlantic and Gulf Coasts and is the only *Menippe* recorded in Texas waters. Its range is from North Carolina to Mexico. Although not abundant at any point, it has been taken in commercial quantities in Southern Florida for many years and was caught and sold to Port Aransas restaurants thirty to forty years ago. Florida still produces about a million pounds of stone crab meat a year (see Johnson 1967). Although a few stone crabs taken commercially in Florida were caught by hand in former years, most were taken in traps set for the marine crawfish (*Panulirus*), but unlike the crawfish, were consumed locally.

To date, no distribution study of this crab on the Texas coast has been made. On the South Texas coast the crab has been found in abundance only on the mud flats of Harbor Island between Aransas Pass and Port Aransas, on the mud flats behind Mathew's wharf, along the breakwaters near Rockport and along the south jetty on Mustang Island. Dr. Joel W. Hedpeth and the second author saw a colony on the mud flats in Mesquite Bay just inside of Cedar Bayou Pass. Fishermen report the crab from deep waters of the Gulf of Mexico in the vicinity of wrecks.

Although the distribution of stone crabs is highly localized, they have been taken in South Texas from every type of bottom, (rocks,

sand, shell, clay, and mud). Apparently the crabs prefer the vicinity of oyster reefs or the rocks along jetties, which are artificial, or the offshore reef areas.

Whitten, Rosene, and Hedgpeth (1950) have recorded distributions of this crab along the jetties of Texas passes. Gunter (1950) recorded specimens from the area under study and from Copano Bay at a salinity of 11.6 parts per thousand, the lowest known where the stone crab has been collected.

Measurement Ratios

All specimens examined came from inside Aransas Pass, that is the bay area of South Texas. In the small and large specimens of both sexes examined, the length of the carapace was 1.3 times the width. In virtually every case, the width of the major chela times 2.8 equaled the width of the carapace. This ratio was useful in determining the size of a crab which had lost a major cheliped. There was a proportional increase in length of the major and minor chela, but this increase was not proportional to increases in the dimensions of the carapace. The ratio between the width of the major chela and the width of carapace probably exists only when the major chela has never been lost.

In proportion to the width of carapace, the frontal width of immature specimens is much greater than in large specimens. Possibly this can be used as an index to the ages of individuals.

THE MUD FLAT HABITAT

Distribution

In some places on the mud flat, stone crabs are apparently colonial and an isolated hole is rarely found and the holes are generally beneath dense clumps of oysters. Stone crab burrows are not readily found. Their concentration seems heaviest where there are scattered clumps of oysters. In some places holes are confined to areas no more than 25 meters square with a few scattered outside of the area of dense population. Within these areas individual holes are at times no more than 20 cm. to 30 cm. apart.

On other parts of the mud flats, holes are scattered over decidedly more extensive areas, much farther apart, and more or less evenly spaced. The reasons for this variance in concentration has not been discovered.

Mounds and Holes

Usually there is a conical depression at the entrance of a stone crab burrow, where the crab often rests. The hole is ordinarily marked by a mound of mud and debris around and about, which is brought to the surface when the burrow is dug. When freshly removed material is present, there is usually a runway. Stone crab burrows in the Port Aransas area have not been observed with bits of freshly broken oyster shell about the entrance. Efforts in the field to recover

bits of broken oyster shell similar to pieces of shell broken by stone crabs in the laboratory have been unsuccessful.

On the other hand, Gunter and Hedgpeth have reported verbally that stone crabs on mud flats in Mesquite Bay almost invariably have cracked oyster shell around the margins of their holes. According to Menzel and Hopkins (1955, Fig. 7) the same is true in Louisiana.

Neither the size of a stone crab hole nor the size of the mound is indicative of the size of the crab within the hole or the burrow. Of ten measured holes and mounds, the smallest hole (45 cm. x 35 cm.) contained the largest crab (111.4 mm.). A 90.3 mm. wide stone crab was taken from a hole measuring 91 cm. x 61 cm. The mound around the second hole (206 cm. x 33 cm. x 9.2 cm.) had almost three times the cubic content of the first (162 cm. x 18 cm. x 6 cm.). Presumably, much of the mound around the first hole was washed away by the tide, an action which would not only decrease the size of the mound, but also the size of the hole. Further observations indicated that no relationship existed between the size of the stone crab hole, the mound, and the crab itself.

Burrows

Small stone crabs apparently do not dig burrows, but simply conceal themselves in crevices of rock or shell, or beneath rocks or shell. Large crabs may do the same thing under stress. A large crab running from the second author went to a clump of oysters, lifted it up, crawled under and let it down again and was as well concealed as if it had lowered a trap door over itself.

The smallest crab (43.2 mm.) found in a true burrow had hollowed out a spot approximately three times the depth of its body beneath a rock. The burrow went only far enough beneath the rock to conceal the crab from directly above or behind. The burrow had no hole, but at its entrance was a round mound (13 cm. x 13 cm.) of shell fragments (on a shelly bottom) and debris. The crab lay sideways in the burrow with the minor chela toward the entrance. There was a smaller stone crab beneath the same rock, but not within the burrow. All rocks on this coast are artificial, and are found only around jetties and where ballast was dumped by sailing ships. The "worm rock" of the Laguna Madre is in a different category.

All stone crabs observed between 44 mm. and 73 mm. wide had burrows going straight down for 25 cm. to 60 cm. Here they leveled off, or might rise or fall, and make several turns. In all cases, burrows of this type ended blindly with no chamber and with the crab sideways at the end of the passage with the minor chela toward the entrance.

All crabs which measured 75 mm. wide or more which were taken from burrows had the kind described by Rathbun (1930) as typical: it extends horizontally or obliquely from one bank of the hole. In burrows of this sort, the crab has a chamber at the end of the passage where it lies facing the entrance. Burrows of this type containing 90 mm. or larger crabs varied in depth from approximately 20 cm. to 75 cm.

Commensal Organisms

Organisms from the Burrow — On January 8, 1948, the following animals were taken from a stone crab hole: 60 mud crabs, *Eurypanopeus depressus* and/or *Panopeus* sp., ranging in size from 3.1 to 17.1 mm., one grapsoid crab, *Pachygrapsus transversus*, 17 hermit crabs, *Clibinarius vittatus*, 9 grass shrimp, *Palaemonetes vulgaris*, 2 mussels, *Brachidontes recurvus*, one scallop, *Pecten* sp., an unidentified nereid worm and five gobies, *Gobiosoma* sp. and *Gobionellus* sp. There were one or more uncollected pistol shrimp, *Crangon* sp. within the hole. There was a clump of oysters in the hole.

On February 7, the burrow of another stone crab was explored in the same manner. The burrow contained approximately 300 oysters in two clumps. None of the oysters were longer than 70 mm. In addition the burrow contained 52 mud crabs from 3.0 to 23.4 mm. wide, three pistol shrimp (one collected — 48.6 mm.; others escaped to burrows outside of hole). Twenty-four grass shrimp from 20 to 32 mm. long, 3 hermit crabs, two conchs, *Thais haemastoma*, (11.8 mm. and 9.7 mm.), and a few scattered acorn barnacles and mussels, 5 unidentified clams, an unidentified sea anemone, and many small amphipods and gastropods. The tube worm, *Eupamotus dianthus*, was numerous in the hole and throughout the area.

Subsequent checks showed that the toad fish or oyster dog, *Opsanus beta*, and the striped killifish, *Cyprinodon variegatus*, are also found in and around stone crab burrows. That these and other organisms should be found in stone crab burrows is not surprising, as they often contain the only water left on the mud flat at low tide. For this reason stone crabs exert a very strong ecological influence, especially in areas of extensive flats exposed by low tides frequently and periodically. Their homes are the last refuges of many small and weakly motile animals that could not reinvade the flats again quickly or easily, between tides. In short, were it not for the stone crabs the life complex of the shallow flats would be considerably different from what it is.

Organisms from the Crab — In this area, stone crabs are rarely found with external calcareous growths. A tube worm was found on the merus (wrist) of the minor cheliped of a stone crab taken on the mud flats January 30. In the latter part of August, a female specimen from the south jetty was taken with a very small acorn barnacle, *Chelonibia patula*, in the median sulcus. It is well known that this barnacle only settles upon living organisms and is chiefly an associate of turtles. This barnacle disappeared before the first of October. Probably stone crabs remove the calcareous organisms that strike on their bodies.

NATURAL HISTORY

Numbers and Sizes of Specimens Recorded

Efforts were made to collect, examine and measure 100 stone crabs a month, but it was found that between January and June the tide was too high to permit collection of a significant number of crabs. The following table is based on those individuals taken from the south jetty of Mustang Island only:

TABLE I

Measurements in millimeters of stone crabs taken from the south jetty (Mustang Island) of Aransas Pass.
(1947-48)

	December	January	June	July	August
Number	10	45	71	73	95
Range, Width of Carapace	9.8 to 17.1	5.5 to 49.0	4.2 to 74.6	3.9 to 80.0	4.8 to 62.4
Mean Width of Carapace	12.32	22.53	24.97	29.95	24.74

In January, seven collecting trips were made along the jetty to obtain the 45 specimens measured, their collection requiring diligent search. Four trips were required to collect the 71 individuals measured in June, 3 trips for the 73 in July, and 2 trips to collect the 95 measured in August.

One out of every 4.7 individuals examined during the December-January period measured 12 mm. or less across the carapace; for the May-June period, one out of 8.9 individuals; and for the July-August period, one out of 6.5 individuals. Except in January, one or more 5 mm. wide individuals were recorded each month.

These data would indicate that the number and sizes of stone crabs increased from January to July, and that the number continued to increase through August. Since there was a significant change in the ratio of males to females (from 5.0 to 1 to 2.65 to 1, see following section) it appears that there was an apparent influx of small females to the jetty area. The finding of very small individuals throughout the study period but only one berried female would indicate that the stone crab breeds over a long season, but outside of the area of study.

Breeding

Of 92 female stone crabs examined only one, a 33.8 mm. specimen, taken August 1, was berried. A 107.9 mm. crab taken on the mud flats July 23 extruded eggs in the laboratory in mid-August.

Sex Ratio

The ratio of males to females of specimens for the December-January period on the basis of 61 individuals was 4.28 to 1; for the May-June period on the basis of 160 individuals, 5.00 to 1; and for the July-August period on the basis of 175 individuals, 2.65 to 1. The sex ratio on the mud flats from May through July was 5.2 males to 1 female. No survey was made of the mudflats in August.

FIELD BEHAVIOR

Activities in the Field

It is generally believed that stone crabs are nocturnal, but individuals have been observed abroad throughout the day and night. Surveys of stone crab holes made on the mud flats showed that ap-

proximately the same number of crabs were in their burrows or holes around midnight as during the daylight hours. A field trip made to the flats on February 7 on an extremely foggy morning revealed that fewer crabs were in their holes or burrows than ever observed before or since. Although crabs kept in the laboratory have been more active at night than in the day, these observations might indicate that the crab is crepuscular rather than nocturnal.

Apparently stone crabs prefer to rest in their holes near the surface rather than deep in their burrows. Day and night they have been observed lying sideways in their holes at the entrance of the burrow always with the minor chela outermost.

Eyesight — Although an observer is often able to see a crab in its hole from a distance without being noticed, even the stealthiest movements near the crab are detected. Probably little vibration is transmitted through the soft silt and mud of the flats, and as ripples do not reach the crab when the banks of its hole protrude above the water level, the crab probably has a keen sense of vision. Seemingly cautious movements at night by flashlight or gasoline lantern are no more readily detected by stone crabs than are comparable movements by daylight.

Defense Patterns

As the observer nears the crab hole, the crab will crouch momentarily in an apparent effort to hide. If the observer continues his approach, the crab retreats slowly out of sight into the entrance of the burrow. When the hand is placed in the hole, the crab pushes it away with a quick lateral motion of the cheliped and retreats about half way down the burrow. If the hand is thrust after the crab, it will again push the hand away and retreat to the chamber at the end of the burrow. Here it digs its legs into the mud and presses its body and chelipeds against the walls of the chamber. No further effort to push the hand away is made. If the hand is withdrawn from the burrow, the crab will follow up the passageway shoving the hand ahead of it. If the hand is again thrust into the burrow, the crab will retreat once more to the chamber.

To capture a crab in its burrow, the hand should be run over the top of the carapace and hooked behind the crab. A firm, steady pull will then dislodge the crab. If the collector's grip on the crab is not firm, or if he hesitates or fumbles about in the burrow, the crab will often pinch the hand slightly. No effort to hold on is made and the hand can be withdrawn easily with little chance of injury.

A crab approached while abroad on the mud flats will crouch beneath the nearest clump of oysters or rocks with the chelae across the buccal cavity and make no attempt to move off unless touched. Then it will shove the hand away and move from the area so rapidly that it is often difficult to capture if there are obstacles in the neighborhood.

On the night of July 23, a crab was observed dragging an oyster across an open patch of mud. When this crab became aware of the observer's presence, it reared back, raised its chelipeds and brought them together several times with a loud click, while attempting to move off. This reaction is similar to a defense pattern of the blue

crab, and is peculiar to certain individual stone crabs. Only one other crab observed (in the laboratory) exhibited this reaction.

On January 30, immediately after a severe freeze, it was noticed that many of the crabs had plugged the entrance to their burrows with bits of debris and mud. This was near noon, and all crabs observed were in their holes sunning themselves. The plugs were still in place, but they had been forced down to make a passageway large enough for the crabs to ease in and out. As this phenomenon was not observed in warmer weather, it is assumed that the plugged burrow is a defense against cold weather rather than against attack.

As is the case with many crustaceans, the stone crab will readily autotomize its appendages to prevent capture. That is, if one grips one or more legs or a cheliped when the crab has a hold on a solid object, the crab will break off the members. Often a crab will autotomize a cheliped if it is caught by the body while gripping a heavy object. One crab was allowed to grip the edge of a small dip net by which it was picked up. The crab, instead of releasing its grip on the net, autotomized the cheliped. This is similar to a defense pattern of the ghost crab as described by Cowles (1908).

A stone crab, when gripping an object such as a stick or pencil, will not release its hold even if spun violently around. The fingers of the chela can not be pried apart, nor can the crab be readily removed from the object gripped. This grip is so strong that one large male (111.4 mm.) in the laboratory crushed its own chela and bled to death when it gripped a hard object in the tank. The hold is released gradually, and after the releasing motion is begun, the crab will not fully retighten the hold.

Large stone crabs are capable of inflicting sharp pain by digging their spurs (glabrous tips of the dactylus) into the hand upon capture, although they are incapable of drawing blood in this manner. This reaction may be an attempt to grip anything that might prevent capture. If attacked from the rear, the stone crab will often stab at or push away the offending object with the third and fourth legs.

Stone crabs, especially the small individuals, will often feign death upon capture. The ambulatory appendages are folded against the body and the open chela are extended as far beneath the body as possible so that much of the abdomen is protected. The chela are held one over the other (usually the minor chela on top) so that an object may be placed in both chelae at once. Rough handling will usually induce this reaction in very small crabs, but it is rare with larger (80 mm.) specimens. Possibly, this position is assumed to allow wave action to transport the crab from place to place, or it may be related to the "eierschutzreflex" of Bethe (1898).

The stone crab has an irregular patch of oblique ridges on the inner surfaces of both chela known as stridulating organs. In small specimens, these are rubbed vigorously across what appears to be the second and third teeth of the carapace to produce a sound not unlike that of the field cricket. Stridulation in larger specimens has been heard and seen only once (86.6 mm. female). In this case, it was much more erratic than in the younger specimens, the stridulating organ only occasionally striking the edge of the carapace. The sound pro-

duced is similar to that of a smooth file drawn across the ridge of a walnut shell. The purpose of this action has not been determined.

When away from their holes, large crabs have been seen to move their bodies in a slight lateral motion to cover the edges of the carapace with mud. Often small depressions are hollowed out in this manner, but the outline of the body is usually plainly discernible.

In the laboratory, the stone crab has been observed to exhibit the "Aufbaum" reflex when disturbed. The crab fully extends both open chelae and raises the body to a position almost perpendicular to the ambulatory appendages and the plane of support. The crab will follow a moving object with movements of its body almost to the point of falling over backwards. The position of its legs is rarely changed. A touch on the outer surface of the chela will cause a slight twisting motion of the body toward the offending object. A touch on the inner surface of the chela causes a quick hugging or clasping motion. At the completion of this movement, the crab returns to the original position with the chelipeds extended. This reaction does not take place unless the crab is actually touched.

Small stone crabs (20 mm. or less) will attack a moving object by lunging out and grasping the object between the merus and manus and pressing the tuberole of the merus against it. This reaction has not been observed in larger crabs. Whether this is a defense reaction or a method of food getting has not been determined.

Two stone crabs, excited by rough handling of their container, were observed fighting. One of the crabs caught the other's leg. The second crab was able to twist around and force the first to release its hold by prying with the major chela. Stone crabs will autotomize their legs if caught by another crab.

Regeneration and Growth

Although no data have been taken, field and laboratory observations indicate that, as is the case with most crabs, the period between moults increases as the crab becomes larger. The duration of the "soft" stage is much longer with a large crab than a smaller one.

The rate of regeneration of lost appendages is proportional to the periods between moults. That is, a small crab regenerates lost appendages much faster than a large one. Apparently, the ambulatory legs are fully regenerated at the first moult after their loss. At the first moult after the loss of a cheliped, the regenerated member is smaller in size than it would be had it not been lost but is functional. As several crabs have been collected with two minor chelipeds, it is assumed that after the loss of a major cheliped, a new minor cheliped is regenerated. Whether this regenerated minor cheliped is replaced by a major cheliped the second moult after its loss has not been determined. This is probable as the number of crabs collected with two minor chelipeds is very much less than those collected with either or both chelipeds missing.

FOOD HABITS

Field Observations

Material for all field experiments in the vicinity of Port Aransas was set out in wire baskets screened with one-fourth inch mesh

hardware cloth. Although hardware cloth does not completely prevent entrance of oyster predators, stone crab predation at Port Aransas was negligible except in May and June. When checks were made during these months, stone crabs were found in oyster baskets at three of four stations.

Although no record was kept of the number of stone crabs found at these stations between October 1947 and March 1948 it is virtually certain that these six baskets had not contained more than a half dozen crabs, all of them very small. No stone crabs were observed in the oyster baskets in April.

When the baskets were re-opened in May for a check of growth and mortality, 36 stone crabs ranging in width from 16.1 mm. to 61.6 mm., were found in the six baskets. From each of two of these stations, a basket of oysters was chosen for a study of stone crab predation. The results of this study are given in Table II. The figures are based on the total number of oysters dead, not on the total number of oysters in the baskets.

Boxes classified as untouched by stone crabs had no marks on them such as a stone crab would leave. Those marked, "*Martesia* removed, but not killed by crab," had one or more boring clams picked from the shell by the crabs but had their hinges intact and were without chips, cracks, or breaks along their valve edges which would affect perfect closure of the oyster. Death of these oysters was attributed to causes other than stone crab predation.

Boxes with sprung hinges, separated valves or chips or holes which would permit a stone crab to reach the oyster itself were considered stone crab mortality. All shells (unmatched valves) were considered deaths attributable to stone crab predation.

The probability that this is an over-estimate of the number of oysters killed by stone crabs should be pointed out. Dr. S. H. Hopkins (private conversation) stated that after eating oysters the stone crab often cracked the shells in order to reach shell parasites they contain. It is conceivable, then, that the crab would also crack the shells of dead oysters for the same purpose. A few of the shells classified as victims of stone crab predation were so small that it is probable that they came from spat attached to some of the oysters. Death of these could be attributed to the weight of the oyster or pressure from adjacent oysters preventing the spat from opening their shells. Boxes could have been broken apart in handling before the study was made.

It is possible that an influx of stone crabs from another area was responsible for the entire increase in mortality at these stations. This, however, is not probable as there were other stations in the immediate vicinity as accessible to entrance by stone crabs in which no crabs were found. It is more likely that the stone crabs entering the three stations were attracted by odor or some other stimulus emitted by dead or dying oysters.

It will be noticed that there was a very sharp increase in mortality attributable to stone crab predation at Station 1 between May 17 and June 24. Between these dates the top of the basket was lost which allowed stone crabs to enter and leave the basket at will. On June 24, no stone crabs were found in the basket, but it contained 7 living oysters all with one or more boring clams picked from their

TABLE II
STONE CRAB PREDATION ON OYSTERS AND MARTESIA
AT PORT ARANSAS

	Station 1 5/17/48	Station 2 5/17/48	Station 1 6/24/48	Station 2 6/24/48
Number of boxes untouched by crab	38	72	2	28
Number of boxes with <i>Martesia</i> removed, but oysters not killed by crab	95	38	15	1
Number of boxes with sprung hinges or with chipped or separated valves	27	6	13	3
Shells				
With <i>Martesia</i> removed	0	2	1	0
Without <i>Martesia</i> removed	3	4	3	0
Total mortality	163	122	34	32
Total deaths attributable to stone crab predation	30 or 18.4%	12 or 8.8%	17 or 50%	4 or 12.5%

shells. A calculated 32.7% of the mortality on this date was due to the added accessibility of the oysters.

Laboratory Experimentation — The writers have detailed descriptions and tables of experiments concerning stone crabs eating oysters in the laboratory, which are too long to present but we shall attempt to adumbrate them here.

One 62 mm. female ate 15 oysters, ranging from 20 to 44.5 mm. in length between December 2 and March 23, a period of 111 days—or one oyster every 7.4 days.

Eleven crabs (24.5 to 48.8 mm. in width) were placed on 20 spat on February 6. Thirty-three spat were eaten in 50 days.

When a clump of oysters estimated to consist of 175 individuals from 15 mm. to 60 mm. in length was placed in the aquarium, the crabs killed one oyster per crab every 5.4 days until July 1. In May and June in this tank three crabs were apparently killed by their mates and eaten.

Other Foods — Since the stone crabs used in the experiments were provided only oysters as food the results of the experiments are not indicative of the number of oysters a stone crab will kill under natural conditions. In an effort to find other items of food taken by the stone crab in addition to oysters, one or more of which might serve as a control for laboratory determination of the rate of stone crab predation, a food preference experiment was set up. In this

experiment, oysters were used as the control item of food; i. e. oysters were always available to the crabs along with some other item or items of potential food. An effort was made to offer the crab all macro-organisms found in its mud flat habitat.

Superficial examination of the data and other observations indicate that the crab prefers acorn barnacles (*Balanus eburneus*) to any other items of food offered. Generally, small oysters and spat are eaten before large oysters. The stone crab seems to prefer natural or uncultured oysters to single or culled oysters. Because of the difficulty of weighing and evaluating the other items of food eaten by the crab in this and other experiments the data are presented in discussion form.

Conchs — On January 13, six stone crabs ranging in size from 13.5 mm. to 101.8 mm. were placed in an aquarium with 145 conchs, *Thais floridana*. On January 16, the crabs were removed from the aquarium and its contents examined. Twenty-eight conchs had chipped or cracked shells. A broken and partially eaten conch was removed from the maxillae of the largest crab.

February 6, twenty-four conchs were placed in an aquarium with two stone crabs measuring 84.1 mm. and 52.2 mm., the latter without the minor cheliped. February 23, 17 days later, 11 conchs were dead, 7 of them cracked and eaten by the crabs. The mean water temperature for this period was 11.6° C.

Conversely, a conch was observed eating a small crab in the laboratory. The proboscis was inserted above the *basis capituli* of the left cheliped. The crab had neither cheliped. As the crab was moribund when observed, it was assumed that the conch killed the crab.

Roughly, one out of five conchs collected from the south jetty at Port Aransas in mid-August had chipped or cracked shells similar to those attacked by the crab in the laboratory.

Flatworms — A series of stone crabs brought in for measurement and examination was placed in a tank containing several sea anemones and a large flatworm presumed to be *Stylochus ellipticus*. The following day the worm was gone from the tank, presumably eaten by a stone crab.

On May 15, a flatworm known to be *Stylochus ellipticus* was placed in a finger bowl containing a 16.2 mm. male stone crab and a series of five spat. Almost immediately the crab started across the bowl toward the worm. As the crab neared the worm, it feigned an attack on a piece of tar in the bowl, then pounced on the worm seizing it basket fashion with the ambulatory legs. The crab had difficulty retaining the worm which several times almost flowed from beneath the crab. Each time the fourth legs were brought to bear and escape prevented. Once, the crab was frightened away from the worm, but it returned immediately. Further attempts to frighten the crab away from the worm resulted in the crab retreating with the worm. The worm was dead and partially eaten 15 minutes after it was placed in the bowl.

The Boring Clam — Two lots of oysters, one from Copano Bay and the other from Tin Can Reef, were brought to the laboratory and deemed unsuited for physiological experimentation because of a

heavy infestation of the boring clam. These oysters were allotted to the writers for use in stone crab experimentation.

When the oysters were offered to stone crabs, clams were removed from many of them without injury to the oyster. In two instances after virtually all of the clams were removed, the shell was so thin that it was broken by hand.

The Mud Worm — A stone crab was observed attacking a mud worm, *Polydora websteri*, only once in the laboratory. This worm escaped the crab by autotomizing several caudal segments.

Jellyfish — On December 2, a small stone crab on the south jetty was seen eating a cabbage-head jellyfish, *Stomolophus meleagris* Agassiz, which had been stranded on the rocks by the tide. On June 29, a small cabbage-head was placed in an aquarium with an 86.6 mm. female and 76.4 mm. male stone crab. After the jellyfish died it was partly eaten.

Other Crabs — On December 16, a fragment of a grapsoid crab, presumably *Pachygrapsis transversus*, was removed from the mandibles of a stone crab collected on the mud flats behind Mathew's wharf. Since several of these crabs were found dead on the flat at this time, it is probable that the grapsoid crab was dead before the stone crab started to eat it.

On January 5, a stone crab hole on the mud flats of Harbor Island was explored. The burrow was not found, but a small blue crab, *Callinectes sapidus* Rathbun, with a freshly broken movable finger was collected. This crab was placed in a canvas bucket with two stone crabs (76.4 mm. and 80.0 mm.) where it sustained a similar injury of the other chela.

These three crabs were placed in a large tank on our lower dock. The following morning, the blue crab was dead and partially eaten by the stone crabs. Further efforts to provoke stone crabs into attacking a blue crab failed.

The hermit crab, *Clibinarius vittata*, was eaten by stone crabs in the laboratory several times. Field observations indicate that the stone crab or some other animal capable of breaking a shell occupied by a hermit crab often preys on hermit crabs.

Cannibalism — That stone crabs prey on one another in captivity has been shown many times. Whether this is the case in nature when food becomes scarce is unknown.

Diatoms — On many occasions, stone crabs were observed using their ambulatory legs to place bits of detritus from the bottoms of aquaria between their maxillipeds. Microscopic examination showed that this litter contained large numbers of diatoms. Frequent repetition of this act and the fact that the gut often contains vegetable matter suggests that diatoms and possibly other algae may constitute an item in the diet of the stone crab.

Barnacles — Laboratory experimentation tends to indicate that the acorn barnacle, *Balanus eburneus* Gould, is a favorite item in the diet of stone crabs.

Fish — Whether or not stone crabs kill and eat fish has not been determined.

Pistol Shrimp — Pistol shrimp would probably not be as plentiful in the neighborhood of stone crab holes if stone crabs preyed extensively upon them.

Carrion — In this area, it is not uncommon to take stone crabs on chunks of meat used as bait for blue crabs. This would indicate that stone crabs will feed on bottom refuse.

Mussels — The common mussel, *Brachidontes*, was often eaten by the stone crab from "natural" clumps of oysters.

DISCUSSION AND SUMMARY

The Mud Flat Habitat

In the vicinity of Port Aransas, stone crabs are somewhat gregarious. They seemingly prefer to inhabit areas in the immediate vicinity of oyster beds or the rocks along jetties. There is no particular relationship between the size of the stone crab hole, the size of the excavation mound, the depth of the burrow and the size of the crab itself. Almost invariably, stone crab holes in this area contain clumps of living oysters. Many animal forms are found in stone crab holes at low tide.

Natural History

Incomplete data indicate that the stone crab population increases from January through August. Apparently the peak of the breeding period comes before May, although immature individuals were recorded throughout the period of study. Scarcity of berried females indicated that ovulation probably occurs outside of the study area. The only berried female recorded, a 33.8 mm specimen, was taken August 1. As the ratio of males to females along the south jetty dropped significantly in July and August, but remained more or less constant on the mud flats, there must have been an influx of small females to the jetty area from a nearby area other than the mud flats. As there was a large population of males along the jetty and as the small females appeared to be sexually mature, this influx was possibly caused by a mating stimulus.

Field Behavior

Frequent observations of stone crabs abroad in the field both day and night, and the finding of many empty burrows on a very foggy morning indicate that the stone crab is probably crepuscular rather than nocturnal. The crab seems to prefer to rest in its hole rather than in its burrow. Usually, the crab will be found in its hole both day and night with the minor chela outermost.

Defense Patterns

Stone crabs exhibit many behavior patterns which have been observed in other crabs.

They will readily autotomize any or all appendages to prevent capture, or to stop excessive bleeding.

Ambulatory legs are sometimes folded around the body with open cheliped extended as far as possible beneath the body. As this position is more easily induced in female specimens, it may be the "eierschutzreflex" of Bethe, or it may be a position assumed to allow currents and wave action to transport the crab.

Stridulation has been observed in both small and large specimens.

Stone crabs will often place both chela before their face and make an apparent effort to duck behind them. When this position is assumed, the eyes are always extended.

Stone crabs will almost invariably push an intruder away rather than attack with the chela. A quick but powerful lateral motion of the cheliped is used.

The "Aufbaum" reflex is more common with large individuals. The crab raises its body to an almost perpendicular position and fully extends both open chelae.

Stone crabs, both in the field and in the laboratory, have been seen to raise the chelipeds and bring the chelae together several times with a loud snap at the approach of an intruder, a reflex common to the blue crab.

Plugging of burrows was observed only during a very cold spell.

Stone crabs often hug or clasp objects to them forcing the tubercle of the merus against the object in a manner which can be quite painful if a finger is seized.

Often a stone crab in a burrow or crevice of rock will press its body and chelipeds against the walls making it difficult to seize and remove the crab.

Ordinarily stone crabs adopt a passive means of defense. This is fortunate, as the crab is very strong and might easily remove a man's finger.

Stone crabs are able to conceal themselves quickly beneath objects or obstructions. They will often take advantage of the silt which collects on their carapace and dig small depressions for concealment on a mud bottom.

Stone crabs have a very strong influence on the life of sand and mud flats that go dry with wind or lunar tides, because their water-filled burrows are the final refuge of hundreds of small aquatic organisms that cannot withstand drying.

Food Habits

Indications are that the size of an oyster, while important, is not a valid index of vulnerability to stone crab predation. One of a series of stone crabs none larger than 16.0 mm. killed an oyster measuring 38.5 mm. x 25.3 mm.

Laboratory experiments indicate that unless most of the items in the diet of stone crabs are discovered, stone crab-oyster predator relationships cannot be adequately worked out in the laboratory. It seems that experiments in which an item of food is placed in an aquar-

ium containing stone crabs but no control (alternate) food items does little beyond establishing whether the crab will eat the item offered or starve. The amount of food taken would be a poor index to normal consumption.

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